**Historic, archived document**

Do not assume content reflects current scientific knowledge, policies, or practices.

Forest Service Library

# IMPLEMENTS and METHODS of TILLAGE to CONTROL SOIL BLOWING on the NORTHERN GREAT PLAINS

FARMERS BULLETIN No. 1797
U. S. DEPARTMENT OF AGRICULTURE

BARE, DRY SOILS are subject to blowing when the wind velocity is high. Damage from this source has increased during the last few years because of extended drought periods and an increase in the cultivated acreage. Sand and very sandy soils, and some types of heavy clay soils offer so little resistance to soil blowing that they cannot be safely cultivated in the Great Plains and should be kept in or put back to grass. Heavy soils that form tenacious lumps and clods are least subject to blowing, and on them ordinary tillage practices can usually be employed with safety. Between these extremes are the wide group and large acreage of soils that are highly productive, but on which special precautions and methods are necessary to prevent or control soil blowing.

A surface cover of growing crops or of undecayed crop residue provides protection against soil blowing, and cropping systems and cultural operations should be directed to the maintenance of such covers. The condition of the soil surface as to roughness, coarseness, and cover—conditions that resist blowing—is to a large extent determined by tillage implements and their use. The more important implements and their use are discussed in relation to the prevention and control of soil blowing.

Row crops may leave the surface in condition to blow. When such crops as corn and sorghum are harvested, at least 2 rows in 20 should be left standing. If they are pastured, the stock should be removed while there are still stalks enough left to furnish protection.

Strip cropping aids in the control of soil blowing by shortening the distance that loose soil can move and by affording some protection to the strips that need it. If the strips are laid out on contours, there is an added advantage of water conservation, which in turn helps directly and indirectly to prevent blowing.

In parts of the United States wind erosion is a serious problem and has been responsible, to some extent, for the organization of the Soil Conservation Service, which has directed a concerted attack on the problem of soil blowing. It is believed that the information presented in this bulletin will materially aid in arriving at a solution of the problem. By combining this information with new and approved practices recommended by the Soil Conservation Service, soil blowing should be reduced to a minimum.

Washington, D. C. Issued January 1938

# IMPLEMENTS AND METHODS OF TILLAGE TO CONTROL SOIL BLOWING ON THE NORTHERN GREAT PLAINS

By JOHN S. COLE, *senior agronomist*, and GEORGE W. MORGAN, former *associate agronomist, Division of Dry Land Agriculture, Bureau of Plant Industry*

[Prepared in collaboration with the Soil Conservation Service]

CONTENTS



## THE REGION AND THE PROBLEM

IN PARTS of the United States soil blowing has been a serious problem, especially in the region east of the Rocky Mountains commonly known as the Great Plains. Soil blowing may occur frequently in this region, and in most seasons there is some injury to crops. Owing to a number of factors, damage was more pronounced in recent years.

The entire area is subject to irregular rainfall and varying periods of high winds, which often last 3 or 4 days. The average rainfall, while low, is sufficient in most places for fairly successful crop production when it has favorable seasonal distribution, and when other adverse conditions do not occur. When winds and drought come together, soil blowing on bare, cultivated land may occur over widespread areas, causing severe damage and discomfort to entire communities. It is not limited alone to cultivated fields, where seedling crops are destroyed and where the surface soil may be either entirely removed or left piled in drifts, but overgrazed pasture land is subject to blowing, and soil may be deposited on adjacent land, badly damaging crops or pastures. Highways often are made impassable by loose soil, and farmsteads may be damaged or entirely ruined. There is often untold discomfort to the entire population of large areas, and in extreme cases the health of individuals is impaired by breathing large amounts of dust.

During the period 1890 to 1930, the total population almost doubled in the Great Plains States—Montana, Wyoming, North Dakota, South Dakota, Colorado, Nebraska, Kansas, Oklahoma, Texas, and New Mexico. However, even at present this region is not generally thickly populated. Livestock was the chief industry before the rather rapid influx of people, and the revenues were largely derived from the native grasses utilized as pasture or hay.

During the last 20 or 30 years, there has been a decided increase in the amount of land broken from native sod and used for cultivated crop production. The increase in such acreage was stimulated to a great extent by the demand for foodstuffs during and immediately following the World War, and to high prices that continued during that period and until the late twenties.

The increase in the cultivated acreage can be attributed in part to improvements in motor power and farm machinery, which made larger acreages possible without proportionate increases in the amount and the cost of labor. The gas engine was so improved that the tractor was a dependable source of power on the farm, as well as more efficient to operate. With tractor power, more timely operations were possible, as the tractor could be operated long days or even night and day when necessary. The development of the truck and motorcar made it possible to raise cash crops farther from local markets, as they could be hauled many times faster and over greater distances. With mechanical power available, land could be farmed at some distance from the permanent home without providing housing, barns for horses, or storage for grain and machinery. The use of the combine for wheat harvesting was one of the important improvements, because it greatly reduced the cost as compared with the old methods of harvesting and threshing. Tillage implements for tractor use, such as the one-way (p. 13), the tractor plow, and the tractor cultivator, all made possible the increase in cultivated acreage. Moisture conditions in some years were extremely favorable, and large yields were produced. When this happened and prices were good, the individual farmer with increased acreage made a profit. One of the important contributing factors in stimulating the increase in farmed acreage in this area was the chance of large profit in a single season.

However, beginning in 1930 and during the general drought period of 1934–35 which resulted in poorer farm practice and increased abandonment of cultivated land, lower prices prevailed. Damage from wind erosion increased to a high point in 1933–35, although there was no serious damage from wind erosion on the various field stations in this region in recent years, except that which originated on adjoining farms and resulted either in the soil accumulating on the station land as drifts, or in starting "blow" areas by cutting the soil loose. Methods of control were not so well defined during earlier years, and rather serious blowing occurred at some stations in the southern Plains. One of the early practices for conserving soil moisture under dry-land conditions was the maintenance of a dust mulch (fig. 1). As a result of the finely pulverized surface, there soon was damage from soil blowing. Soil investigations

brought out the facts that the conservation of soil moisture was not dependent on the fineness of the surface and that cultivation which eliminated growing vegetation and left a somewhat roughened surface was not only efficient in conserving moisture but also reduced wind erosion.

## SOILS

The soils of the Great Plains have been developed under a grass cover in a semiarid climate and consequently have some elements of uniformity. In more detail, however, they vary widely, both as to their origin or the method by which the parent soil materials were laid down and as to their texture, both of which have an influence on their resistance to soil blowing. The soils of the northern part of Montana and those parts of North Dakota and South Dakota east of the Missouri River have developed from glacial till, and as with other glaciated soils, they vary a great deal. The parent soil mate-

FIGURE 1.—A small field starting to blow. The surface is too fine. The wind has been blowing only a short time, but the soil is beginning to move as shown by the dust in the background.

rials of the remaining part of the Plains were laid down by a number of forces, and include alluvial deposits along stream beds, deposits formed under water in lakes, loessial deposits formed by wind, and volcanic ash and lava. In texture the soils range from heavy clays and adobes through silts to sandy and gravelly loams and dune sands. Over most of the area fertile soils of good texture are available for cultivation, the limiting factor in crop production being an uncertain rainfall.

Regarding the fertility of soils of semiarid land, C. F. Marbut says:

> The humid land forest soils are fertile, chemically so, when first cleared of forests; but the layer containing a high percentage of the constituents of fertility is very thin and is soon exhausted. The soils of the semiarid lands are entirely different in this respect. Not only is the percentage of what we may call fertility constituents large, but the layer in which they are present is thick. Its thickness in feet is as great as is the corresponding layer in the humid forest soils in inches. It is so great that the world's experience up to the present time affords no basis for placing any estimate on the duration of the productivity of these lands.

### ORGANIC MATTER AND HUMUS

The physical property of a soil is influenced by the amount of organic matter present and the state of its decomposition. As a rule soils in the Plains are low in organic matter and humus, in comparison to the prairie soils to the east of them, because the growth of vegetation under natural conditions is lighter. The presence of sufficient crop residue or organic matter in a soil has a mechanical effect in the control of soil blowing, provided it has not decayed to such an extent that it is incorporated with the soil. When these residues are in part above the surface, they prevent surface soil from drifting in much the same manner as clods do. The presence of crop residues in and on the soil is one of the greatest aids in the control of soil blowing. They must be constantly renewed or replaced, as they decay rapidly.

Observations made at several experiment stations are to the effect that soils blow more readily when they contain large amounts of decomposed organic matter and humus, as noted in soils around straw stacks where the straw has rotted; where alfalfa or sweetclover were turned under, and the roots have decayed; or even in dark mountain soils that have been cultivated until native grass roots originally present in dense masses have lost their binding properties.

The following observation was reported in Canada Department of Agriculture Bulletin 179, in 1935:

> Contrary to general opinion, humus in a soil appears to facilitate drifting. Humus consists of decomposed organic matter, chiefly the residues of former vegetation. It gives soil its characteristic dark color. It is to some extent indicative of soil fertility, and in addition imparts to soil several desirable physical properties. In-so-far as it affects soil drifting, however, observers have reported that some of the soils in the park belt of high humus content readily drift when the predisposing causes arise. The reason suggested for this is that humus tends to prevent the soil from forming into clods that are so effective in checking wind action.

### RESPONSE OF SOILS TO MOISTURE

As is generally observed, soils differ greatly in their responses to moisture, and some of these responses are important in the control of soil blowing. Sandy soils, with larger particles and larger pore spaces, absorb moisture more readily and release it more easily than the finer grained clays, in which the pore spaces are smaller and more numerous. Because the particles are held together, soils do not blow when they are wet or even moist. The finer grained soils often retain enough moisture to tide over a blow period without injury, whereas under similar conditions more sandy soils dry out enough to blow.

Most soils in the Plains region form a crust as they dry, especially when the drying is rapid and following a heavy rain. The depth and character of this crust varies with different soils; that formed on the finer grained clays being usually thicker and held together more firmly than that formed on the more sandy soils. Proper tillage operations form clods from this crust and leave a roughened surface that resists soil blowing. Because they are more cohesive, the clods formed on the medium- to fine-grained soils usually resist wind action better than those on the sandy soils.

There are large areas of heavy clay soils in the Northern Plains that are as susceptible to blowing as the lighter-textured soils. When these soils dry, the body is a loose mass of granulated particles. The thin clay crust cracks, and the edges curl and are readily broken down. The fine particles blow away as dust, and the aggregates blow into great dunes like sand. The control by roughening is a very temporary measure. Such areas should be protected with a vegetative cover at the earliest opportunity.

Under certain winter conditions, freezing and thawing may reduce a generally resistant soil to a blow condition. When this happens the surface is fine and loose in the spring, and drifting may be serious. After they are wetted by spring rains, these soils again exhibit their cohesive characteristics and can again be protected from the action of wind.

## DIFFERENCE IN CONDITIONS IN NORTHERN AND SOUTHERN PLAINS

The principles dealing with characteristics of soils that influence their natural resistance to the action of wind are applicable wherever soils blow; but the methods of control vary with local conditions, depending on climate, soils, the use and effect of different tillage implements, different tillage practices, the selection and effect of crops and cropping systems, and the kinds of weeds that are most abundant and the time of year when they grow most profusely.

The problems of the control of wind erosion are somewhat different in the northern and in the southern Great Plains. The winter season is more severe and longer in the northern part, which results in the ground being frozen and covered with snow over a longer period. More of the small grains in the North are seeded in the spring, and when winter grains are seeded they do not produce as much fall and winter growth as they do farther south. In the present stage of evolution of farm practices, the summer fallow is more generally used in some sections of the northern Plains than it is in the southern. It may be somewhat safer in the northern Plains, but in either area it is a possible source of soil blowing. Regrassing presents somewhat different problems in the two areas. In the North there are domestic grasses that can be grown to good advantage for reseeding land taken out of crop production; whereas in the South, grasses native to the area are the only ones proved to be able to withstand drought and heat. The control methods given here apply especially to the northern Plains.

## EFFECT OF CULTIVATION

Some of the soils in the northern Great Plains should not be under cultivation, because they drift so easily. The sandy soils are the most dangerous, as they have very little cohesive quality and when bare will drift easily. It is impossible to cultivate them without pulverizing the surface. Very few or no clods are formed, and those that are formed do not last.

There are large sections in this area with soil that is fertile and light enough to be tilled easily, but light enough that, under some

conditions, drifting may be serious. With proper management these soils can be controlled. The kind and time of cultivation is very important in such soils, because clods can usually be maintained with the proper implements, except under unusual conditions. But with excessive cultivation, the surface of such soils may become so fine that control is difficult.

There are other soils that drift very little, if at all, even when in a fallow condition over the winter. The soil particles are held together very tenaciously, and ordinary tillage practices usually are satisfactory.

FIGURE 2.—Protective cover of stubble left on the surface by the one-way. This field was cultivated with the one-way in the fall of 1935 and photographed in May 1936.

## PROTECTIVE COVERS

Soil blowing does not occur when the surface is protected with either growing vegetation or an adequate cover of undecayed crop residue. Native grassland seldom blows and never drifts, unless badly overgrazed. A thriftily growing crop of small grain soon affords ample protection. Crop residue, either as standing stubble or when partially covered with surface soil as left by some cultivating implements, is effective (fig. 2). The latter is more in evidence in recent years, because with the advent of the combine more of the straw is left standing in the field. The one-way has more general use than the ordinary plow, as there is less trouble with the long straw gathering and choking the implement.

### GRAIN CROPS

The cropped acreage in the northern Plains is largely devoted to spring grains, the greatest acreage being in wheat. A part of the spring grain is grown on fallowed land or cornland, but much

of it is continuously cropped. In the eastern part of the Plains the principal tillage operation in continuous cropping is plowing in the fall, but in the western part it is usually plowing, one-waying, or disking in the spring.

Continuous grain in this area affords much protection for the surface soil, because with proper management the surface is covered with either the crop or stubble most of the year. Land plowed in the fall should be left rough over winter. This affords protection to soils in which the clod structure is tenacious. Soils that slack down quickly should remain in stubble over winter. Land on which cultivation starts in the spring is bare only until the crop makes growth enough to protect the surface. Consequently with continuous grain there is danger of soil blowing on a large scale only in seasons when dry springs prevent early growth of the crop.

FIGURE 3.—A protective cover of combine stubble on plowless fallow. This field has been cultivated with a one-way.

## PLOWLESS FALLOW

The acreage of plowless fallow has increased during the past few years, because yields following it have been almost equal to those following plowed fallow and, on soils that are inclined to blow, the plowless method leaves stubble and trash on the surface which serves to control drifting (fig. 3). The one-way or the duckfoot cultivator is substituted for the plow for the first cultivation, although the disk, especially the newer and heavier type, is sometimes used. These implements operate at a lower cost per acre than a plow and have the added advantage of requiring less time to cover a given acreage, which is sometimes an important factor. The one-way should not be used when stubble or trash are light, as it leaves the soil in a pulverized condition that, without a protective cover, is very susceptible to blowing. For later cultivations, the duckfoot cultivator and the rotary rod weeder are better than the one-way, as they do not destroy the stubble or pulverize the surface soil.

## TILLAGE IMPLEMENTS

Implements for cultivation vary widely in their effect on the soil. Some leave it pulverized, and others form clods; some completely turn the surface, and others stir the topsoil but do not turn it under.

It is common knowledge that the resistance of soil to blowing is in a large measure dependent on the condition of the surface. If bare soil is finely cultivated and smooth, there is danger of drifting. The selection and proper use of implements are important in the control of soil blowing.

### PLOW

Implements developed in recent years have in part replaced the plow, but it still remains the most important one for thorough and general-purpose cultivation. Some of the heavy tractor implements

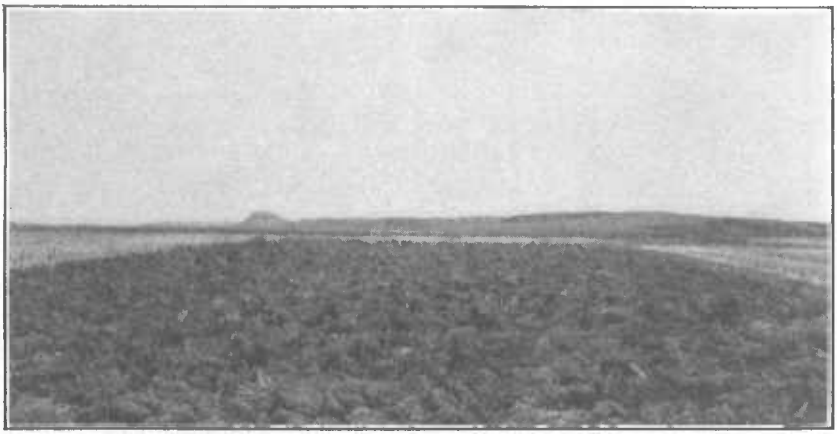

FIGURE 4.—Dry plowing done at Havre, Mont., in the fall of 1935. This soil does not pulverize in the winter by freezing and thawing. The clods break easily when moist in the spring, but become hard when dry and are difficult to work into a seedbed. Some soils disintegrate and pulverize in the winter and blow easily when the spring is dry and windy. Photographed May 3, 1936.

perform certain kinds of tillage to good advantage; but the plow turns under vegetative residue and trash, kills weeds, rearranges the soil structure, improves the tilth, and prepares the foundation for a good seedbed. Recent investigations and experience have shown that annual plowing is not necessary under semiarid conditions. An occasional plowing is desirable, but once in 4 to 6 or 8 years may be sufficient. Plowing leaves no trash on the surface, and in some areas a trash cover is almost imperative.

The surface left by the moldboard plow is usually somewhat rough and loose, and when in this condition it does not blow readily. The degree of roughness depends on the character of the soil and its moisture content when plowed (fig. 4). Because of the friction on the moldboard and the general pushing effect as the soil is turned, there is less pulverizing than with many other cultivating implements. The turning of the soil rearranges the structure and loosens it so that air circulates readily. Plowing soils when they are moist

usually results in a coarse, lumpy, or cloddy surface when they dry. Because heavy soils are cohesive, moist plowing forms more clods in them than it does in sandy soils. There is more danger of plowing the heavy soils while so wet that the entire plowed layer may bake and be a mass of clods, than there is with the lighter ones. Sandy soils usually can be plowed when they contain a high water content, with very little danger of severe baking. Plowing of land to be left fallow or otherwise in a condition that may allow it to blow can be done to advantage when there is an optimum of soil moisture for good tilth. Clods will be formed that can be brought to the surface by later cultivation, where they form a protection against blowing.

The depth of plowing may have an effect on soil blowing, depending on the character of the soil. When the surface is light and the subsurface rather heavy, an occasional plowing that is deep enough to bring up some of the clay may be an advantage, because the clay will form more clods than the lighter surface soil. In the semiarid area the subsoil is usually fertile, consequently it does not decrease fertility to any extent when mixed with the surface soil.

If the lower soil is as light or lighter than the surface soil, there is little advantage in deeper plowing, except to bring to the surface lumps and clods formed by consolidation below the zone of shallower cultivation.

In some sections, the disk plow is used in the place of the moldboard type. It has some advantages, but the effect on the soil is different. In comparison, the disk plow is somewhat lighter in draft, will penetrate drier and harder soils, can be used where there is more stubble and trash without choking, and can be used in some soils that will not scour or clear when the moldboard is used. The disk plow, on the other hand, has more of a pulverizing effect on the soil when it is moist and in condition for plowing. The pulverizing effect of the disk plow is a disadvantage when conditions are favorable for blowing.

### LISTER

The lister is not so well known or in such general use in the northern as it is in the central and southern sections of the Great Plains. It can be used in preparing a seedbed for corn or for the first cultivation of land to be fallowed. In the central and southern Plains, where the season is longer, it is sometimes used for the first cultivation in preparing a seedbed for winter wheat. A five-bottom lister so employed is shown in figure 5. Because the lister leaves the land ridged and rougher than it is left by a plow, it affords greater protection against blowing. In the southern Plains, listing is the operation resorted to when heavy cultivation is required as an emergency measure to stop soil blowing. Listing for this purpose may be solid, or the furrows may be spaced as much as 2 rods or more apart, depending on the severity of conditions, the power available, and the length of time it is estimated that protection may be required. When the furrows are spaced at considerable intervals, the operation is known as strip listing. The purpose of strip listing is to trap the soil that is moving along the surface and prevent it from gathering volume and accelerating the erosion process. Strip listing is often employed

in the attempt to save a crop of grain, especially winter wheat, that does not have enough growth to protect itself. Strip listing of a blowing section of a winter wheatfield is shown in figure 6.

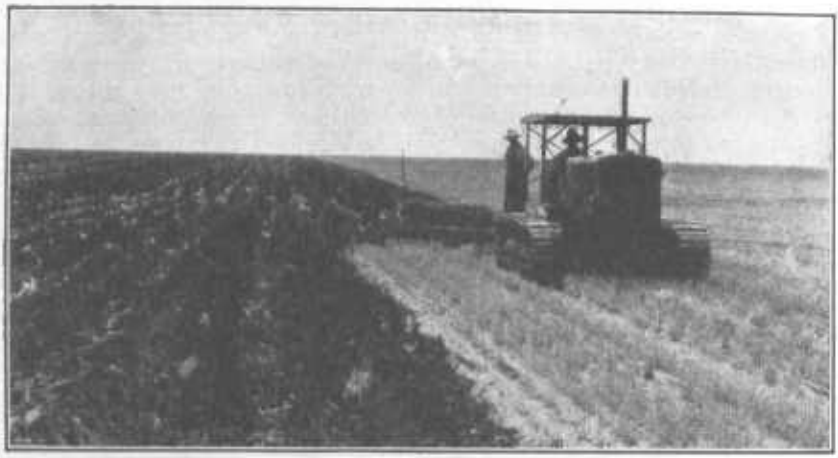

FIGURE 5.—Blank listing in stubble, an operation sometimes employed as the first step in the preparation of a seedbed for winter wheat or for fallowing.

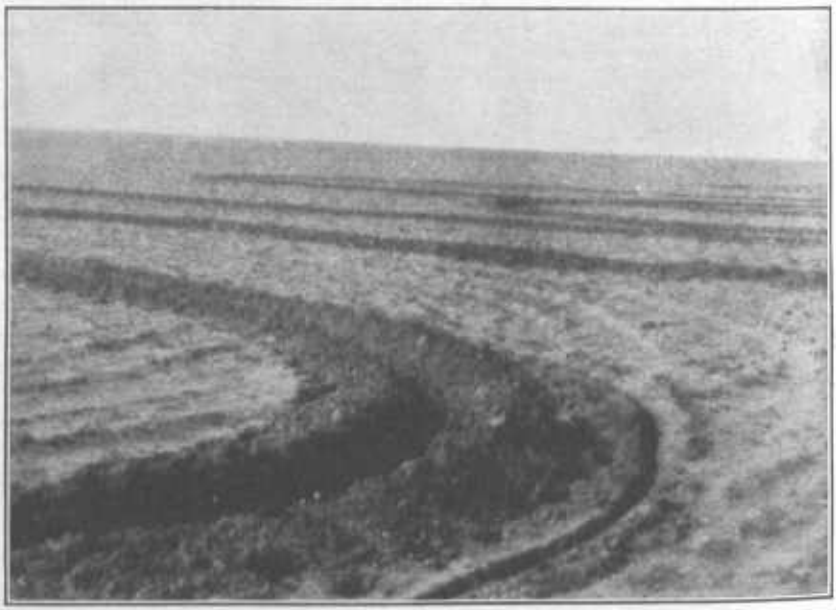

FIGURE 6.—Strip listing (listing one or two furrows at intervals of 2 rods or more). This provides protection against soil blowing for a short time or when only moderate protection is needed. If the furrows fill up, the operation can be repeated.

Contour listing not only protects against soil blowing but conserves water by checking run-off. The increased water supply may promote a greater growth of crop which in itself will protect the soil. A contour-listed field after a heavy rain is shown in figure 7.

An attachment recently developed for the lister throws up dams at intervals in the furrows. The lister so equipped is known as a basin lister. The listing is a protection against immediate blowing, and the blocked, open furrows hold water that otherwise might run off.

### DISK

The disk, or disk harrow as it is sometimes called, has not proved to be generally adapted for the cultivation of bare or unprotected soils in this area. In fact its use is hazardous when soils blow, because it pulverizes the surface soil, does not form clods, and leaves a smooth surface that drifts easily. Following a plow, it may be used

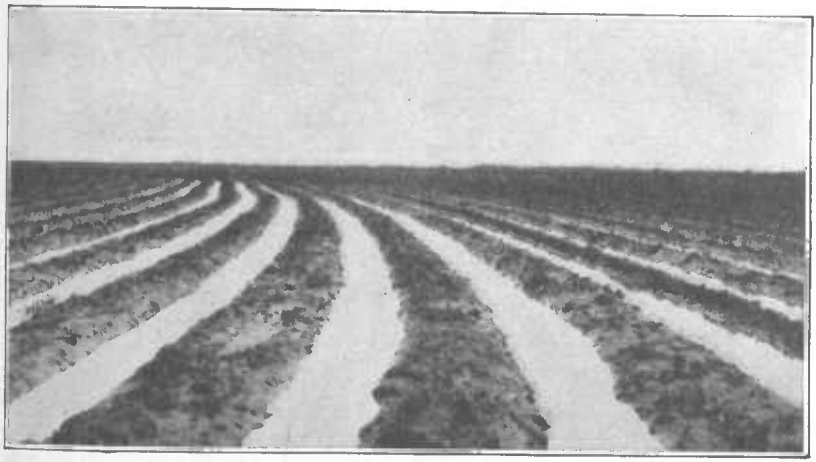

FIGURE 7.—A contour-listed field after a heavy rain.

as a packer with the disks set straight. It can be used to cultivate stubble land, but only the heavier tractor type will penetrate dry soils. It does not eradicate weeds as thoroughly as some of the newer implements and has been largely replaced by them.

### SPIKE-TOOTH HARROW

The spike-tooth harrow fines and smooths the surface soil, and for that reason it is rather dangerous to use unless the soil is fairly moist. It can be used in the preparation of a seedbed in early spring, but it should not be used on summer fallow during the summer or on land that is already fine and in condition to blow.

### SPRING-TOOTH HARROW

The use of the spring-tooth harrow recently has gained in popularity in many areas, especially when used in cultivating clean summer fallow. This implement has a tendency to bring clods and a small amount of trash to the surface, but it cannot be used if there is any large amount of trash, as this gathers on the teeth and interferes with its operation. This implement is economical to use and will clean land of small weeds, but it is not effective when they have attained much size. It leaves the surface loose as deep as it culti-

vates, but this depth is easily regulated. When a soil has a crust that is not too thick, the spring-tooth is very effective in breaking it into clods and leaving a desirable surface condition to withstand blowing.

### FIELD OR DUCKFOOT CULTIVATOR

The field or duckfoot cultivator was developed during comparatively recent years and has been used quite generally over this area. It is probably used over the northern Plains more than any other

FIGURE 8.—The spring-shanked field cultivator with duckfoot shovels in operation. It is most excellent for killing weeds and for bringing clods and trash to the surface on summer-fallowed land or land being prepared for wheat.

tillage implement for the cultivation of summer fallow and for seedbed preparation. It leaves a ridged surface that is desirable when blowing is a factor. Its work is shown in the cover-page illustration. The surface is loosened for 3 or 4 inches and in such condition may dry out to this depth, but it is in excellent condition to absorb heavy rains with less tendency for surface puddling than after many other surface-tillage implements. The arrangement of the shovels is such that there is good clearance, and it can be used on soils where there is some trash. The objections to its use are that the cultivated surface soil may dry out, and it may not entirely eradicate weed growth. It is rather expensive to operate, because of the necessity of replacing the shovels, which wear rapidly. A cultivator of the duckfoot type in operation is shown in figure 8.

By extending the rear gangs 1 foot, this implement does excellent work in wheat stubble without clogging. Its use in this manner is enhanced over the regular spacing of gangs for working in stubble fields in preparation for planting. It is important on blow soils to leave the stubble on the surface for protection.

### COMMON ROW CULTIVATOR

The shovel cultivator commonly used for the intertillage of corn and other row crops can be used very effectively under many conditions to check blowing after it has started or to provide protection against possible blowing. A smooth, unprotected surface soil, such as that from which a row crop has been closely harvested or where a plowed or otherwise cultivated field has been reduced to a blow condition by weathering or beating rains, can be roughened and given protection for a time with such cultivators, which are gen-

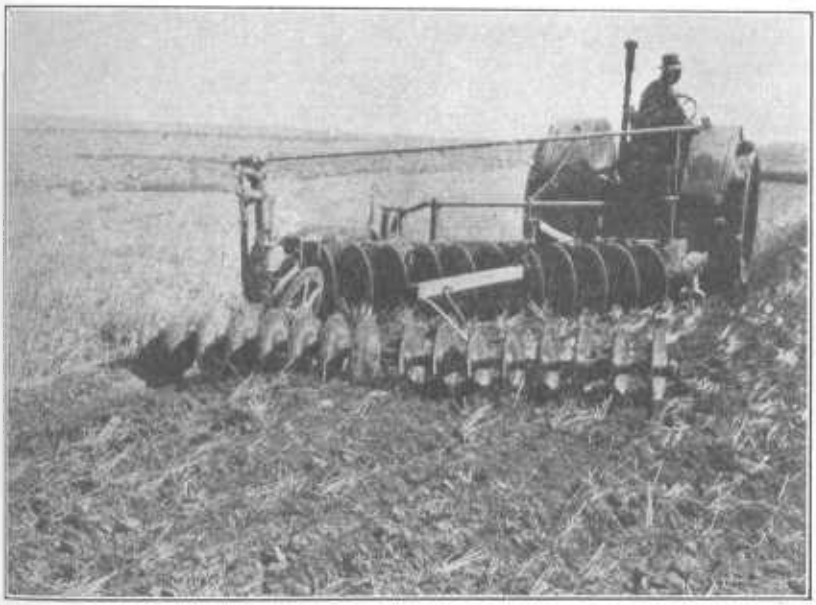

FIGURE 9.—The one-way followed by a disk to pack the soil. This one is operating in stubble left by a binder, which is not so heavy as that left by a combine. The stubble remaining on the surface aids in the control of soil blowing.

erally available in multiple-row sizes. When used for this purpose, it is common practice to remove all but one shovel from each beam. Such cultivation is effective only when the shovels bring to the surface lumps and clods or moist soil that will form them on drying.

Cultivators fitted with only one shovel on each beam can be used in fields sown to small grains that have not developed a protective cover. When such cultivation is necessary, the thinning that is done is likely to be beneficial rather than destructive.

### ONE-WAY

The one-way disk plow is a comparatively new implement sold under several names, such as gold digger, wheatland plow, and others, but one-way is the name most generally used. It is equipped with large disks that are set fairly close together. The entire surface soil is moved when it goes over the ground, and this kills growing weeds. The soil is left in a much looser condition than after a plow. It pulverizes the soil about the same as the old type disk, but is more

effective in killing weeds. Because of its weight, it will penetrate dry soils and is especially adapted for use on the dry, hard ground immediately after harvest of small grains. It can be used where there is a heavy stubble or vegetative growth, and the rotary action of the disks leaves this trash and organic material on or near the surface, where it serves as a good protective covering (fig. 9). Under such conditions it can be used with safety, but the soil is left so fine that, without trash to provide surface protection, it is in condition to blow. Continued use of the one-way on dry soils devoid of cover left many large areas in the winter wheat belt in such condition that the control of drifting was almost impossible. Even where there is stubble or trash, an occasional plowing—deep enough to turn up clods and lumps—is desirable.

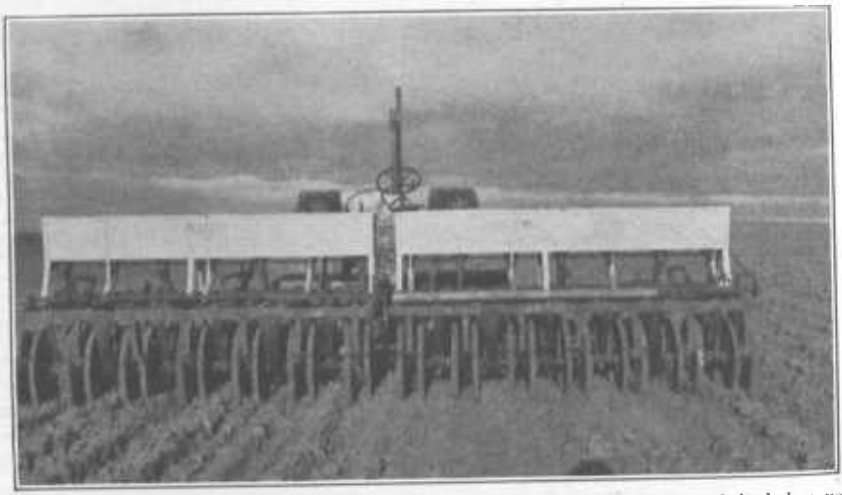

FIGURE 10.—A furrow drill that leaves a desirable ridged condition and is being used to some extent for seeding spring grains on land that may blow. This drill cultivates the land and eliminates weeds before seeding.

### FURROW DRILL

There are several types of furrow drills, but they all leave a ridged surface that resists the action of wind much better than the smoother surface left by ordinary shoe and disk drills. The furrow drill is used more for winter wheat, as it gives added winter protection to the plants and aids in the control of soil blowing. It is also used for spring wheat. One type (fig. 10) is equipped with large shovels that cultivate the entire surface, thus eliminating all weed growth at the time of seeding. This type of furrow drill is sometimes used as a duckfoot cultivator. It is especially effective for emergency cultivation to check a field that has started to drift.

### ROTARY ROD WEEDER

The rotary rod weeder was developed in eastern Washington and Oregon where summer fallowing is a general practice. This implement is manufactured by several companies, but the machines all operate on the same principle. The rod, which may be square, oblong, or round, runs 2 or more inches below the surface, the depth

depending on the condition of the soil. It revolves slowly, the motion being upward on the front part of the rod, which tends to keep the rod pulling downward in the soil and to deposit the coarse material, including the clods, on the surface, with the fine material below (fig. 11). It operates best in fairly loose soil where there are not too abrupt depressions or ridges. It is not adapted to use in stony soils. It clears itself well and can be used where there is trash or fairly heavy weed growth. It is very effective in killing weeds, as most of them are deposited on the surface. It packs the soil to

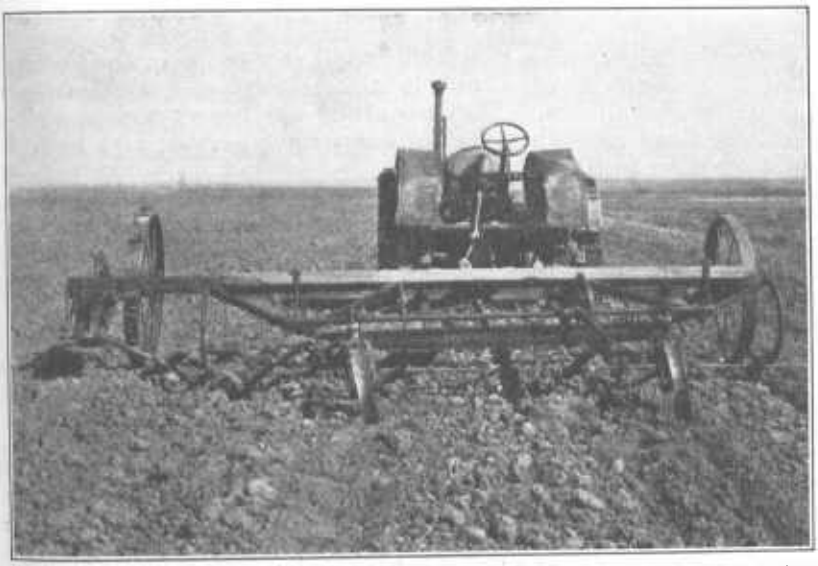

FIGURE 11.—The rotary rod weeder with the rod out of the ground. The surface in the foreground shows the cloddy mulch that it has produced.

some extent just below the surface and is an excellent tool for summer cultivation of fallow, as it so entirely kills vegetative growth that the number of necessary cultivations is small. Its continued use may, however, pack the fine soils and make them impervious to rain. Unless it is used excessively, the rod weeder leaves a cloddy surface that is resistant to the action of wind.

## INFLUENCE OF PRECEDING CROP AND THE TILLAGE METHOD

It is evident that both the preceding crop and the tillage method have an effect on the drifting of soils. In some cases, such as with row crops, it is undoubtedly a combination of both, as in order to kill weeds effectively, cultivation is sometimes done when it puts the surface in condition for blowing. The effects of small grains have been discussed in preceding pages.

### BEANS

From several experiment stations, bean ground is reported as being very susceptible to blowing and difficult to restore to a stable condition. There are probably several contributing factors. The cultiva-

tion of this crop is done in midsummer when the soil is usually dry, but the method of harvest may be more responsible. Beans are harvested late in the summer by means of knives that cut the plants off beneath the surface. Very little binding material is left in the soil and no crop residue on the surface, which is left in a pulverized condition. The suggested remedies are to grow the crop in narrow strips with protection in the form of stubble or growing crops on the intervening strips and to cultivate after harvest with a lister or shovel cultivator, so the surface is left in a roughened condition.

### CORN AND SORGHUM

By far the largest acreage of cultivated row crops in the northern Plains is planted to corn, but in the eastern and southern part sorghum is also grown. The two crops are grown under similar conditions, have somewhat the same growing period, and both are largely used as feed on the farm.

Several experiment stations report more soil blowing after corn and sorghum than from bare fallow. Both these crops are planted with a surface planter as well as in lister furrows, but there is more blowing after surface planting, as the cultivation is often shallow. With the crop using moisture, the soil is often dry when cultivated, especially at the last time over, and this leaves the surface pulverized and in condition to blow. With lister planting there is less trouble, as the cultivation does not leave the surface as smooth as it does after surface planting.

When the most or all of these crops can be left standing on the field there is little danger of soil blowing. This can be done with corn when it is husked in the field, but in this section these crops are largely used for roughage and are removed for silage or bundle feed or they are grazed off in the field. Either method leaves an exposed surface soil that blows easily.

When the crop is harvested with a binder it should be cut with a high stubble, and at least 2 rows in 20 should be left standing. Further protection can be given by cultivation, either with a lister or a shovel cultivator that will turn the roots up on the surface, where they aid in the control of blowing. Grazing these crops closely in the fall or winter is very apt to cause blowing, because the surface soil becomes fine and level from tramping by livestock. Where there is danger of blowing, grazing should be carefully controlled so as to leave enough of the crop to protect the soil.

### POTATOES

The acreage of potatoes is small in this area, and the fields are usually also small, but this crop leaves the soil very susceptible to drifting. When the ordinary digger is used, the soil is pulverized, and there is not enough crop residue to afford protection. Deep cultivation or listing following harvest will aid in the control of soil blowing.

### ALFALFA AND SWEETCLOVER

In several instances there has been opportunity to note the effect of alfalfa and sweetclover as compared to other crops on soil blowing, and the observation has been that blowing was worse after these

two crops. The comparisons have been made where land was removed from the alfalfa or sweetclover sod for 1 or 2 years, so that the original roots were decayed enough to lose their form. The effects of these two crops seem to be to decrease cohesiveness and the number of clods resulting from cultivation, without in any way increasing the binding property in the soil.

### FALLOW LAND

There is probably more blowing from plowed fallow in this area than from any other method of cultivation. The surface is bare and unprotected, and the acreage is larger and more generally distributed than that of any other susceptible method. The fields are usually large, and when blowing starts it is more difficult to control than in smaller fields.

Fallowed land, however, has some advantage over that tilled and cropped by other methods in that the soil is usually moist when it is cultivated, which helps in forming clods. At least, there usually is moist soil near enough to the surface that a cultivating implement such as a duckfoot or rotary rod weeder will reach it. Dry cultivation of bare soils usually tends to pulverize the surface.

If the soil is light and inclined to be sandy, there is no method of bare tillage management that will give even a reasonable assurance against drifting when conditions are favorable for it. There is very little opportunity to create or maintain in this class of soil a cloddy condition that will hold against wind action. It should be handled in such a way as to leave a protective cover throughout the year. This can be accomplished by the plowless method of fallowing, by continuous cropping to spring grain, or by seeding to grass or a permanent legume.

Fallow, however, under proper management can be maintained with a reasonable assurance of safety on the silt loam soils and those of heavier texture throughout the northern Plains. The plowing should be done fairly early in the season and when there is ample moisture in the furrow slice. A certain degree of cloddiness will result, and subsequent cultivation should be such as to maintain a coarse lumpy surface. The rotary rod weeder or shovel cultivators will usually accomplish this result. The rotary rod weeder is especially suited for summer cultivation, as it does not pulverize but deposits clods and debris on the surface. It kills weeds very efficiently, which decreases the number of necessary cultivations. If the fallow is seeded to winter grain, the furrow drill will aid in controlling soil blowing during the winter. If fallowed land is to be seeded to spring grain, the last cultivation in the fall should develop a ridged condition, such as is produced by the duckfoot cultivator, for winter protection.

### STRIP CROPPING

The management of crops in comparatively narrow strips that follow the contours of the field is a device that has long been used in some sections to control erosion. The width of the strips is so adjusted that erosion on an exposed area does not gain volume and become accelerated before it is interrupted by a protected area.

The present discussion is limited to an application of the principle that has come into practice in some sections of the northern Great Plains, first in Alberta, Canada, and later in Montana. In these sections a bare summer fallow was either necessary to successful crop production, chiefly spring wheat, or the response to it so great that it was a preferred method. At the same time, however, large fields could not be summer-fallowed without inviting danger of destruction by blowing. It is said that farmers in a section of Alberta observed that the last place to drift was a strip on the side of the fallow field toward the prevailing wind. These observations soon led to a division of the fields into alternate strips of fallow and grain (fig. 12).

FIGURE 12.—A field being farmed in strips with alternate fallow and spring grain. The strips are 215 feet wide. This field blew when fallowed in a solid block, but the damage has been entirely checked. Note the cloddy surface on the fallow strip. Preventive methods of cultivation are also necessary with the strip method to control blowing.

The width of the strips depends on the danger and severity of blowing to be expected, the greater the danger, the narrower the strips. The width may range from 5 rods or less to 20 rods. The direction of the strips should be approximately at right angles to the direction of the most damaging winds.

Even though the expanse of large fallow fields is avoided by the device of strip cropping, this alone cannot be depended on to prevent blowing. It is still necessary in the management and cultivation of the fallow to exercise every precaution to avoid blowing.

Strip cropping as outlined can be modified to obtain the advantages of water conservation by adjusting the strips to field contours instead of laying them out by compass directions.

Other crops and treatments can be adapted to the practice developed with fallow and wheat. A crop or a cultivation method that leaves the soil exposed during the winter and spring should be in strips alternating with strips that provide protection during that period rather than in large fields across which the soil can drift without interruption.

## REGRASSING

The only permanent remedy for the control of wind erosion on areas that are subject to severe blowing is the establishment of

grasses that are hardy enough to withstand the conditions where grown. When established, grasses provide a vegetative cover, and the mass of perennial root growth results in an increase in soil-binding properties.

There are, however, a number of problems in connection with regrassing, and some of them are rather difficult. The seeds of grasses are small, and they germinate and start to grow best when seeded in moist ground and covered with a small amount of soil. In fact, when this cover is more than 1.5 to 2 inches, the seedlings usually do not emerge. Climatic conditions in the Plains are often dry and windy in the spring season, but seeding should be done at an opportune time when the soil is moist, or in the fall when there is a protective cover. Failures to obtain stands are frequent, unless there are favorable periods of rainfall during the season. Stands that start in the spring may be seriously damaged by heat and drought during the summer, or they may be injured or destroyed by grasshoppers. The difficulty in starting grass increases from north to south in this region, and at the present time no domestic grass is known that will grow in the central and southern Plains as successfully as native grasses.

Crested wheatgrass (*Agropyron cristatum* (L.) Beauv.) is especially adapted for seeding in the eastern parts of Montana and Wyoming and the western parts of North Dakota and South Dakota. If the land is to be left in sod for a number of years, crested wheatgrass is the best variety for seeding in this section, and the yield is more than that of native grasses. It is somewhat more hardy than bromegrass (*Bromus inermis* Leyss.) and much longer lived than slender wheatgrass (*Agropyron pauciflorum* (Schwein.) Hitchc.), which usually lasts not more than 3 or 4 years. The last-named grasses, however, may produce heavier yields the first 2 or 3 years. Seeding habits of crested wheatgrass are better than those of the other two over a period of years, because the slender wheatgrass dies, and the bromegrass becomes sod-bound a few years after seeding.

### EMERGENCY CONTROL

Very effective tillage measures often can be used when a field starts drifting. Soil drifting usually begins in small areas where the soil is less stable or is more exposed than in the remainder of the field. Unless these small areas are brought under control, the drifting may increase; and if the wind continues, damage will become more severe and will spread rapidly over larger areas.

Cultivation of the initial blow areas with a duckfoot, spring-tooth, or common row cultivator with shovels is usually enough to check ordinary soil movement, especially if these implements turn up moist soil or create a cloddy surface. When cultivation in strips will check the drifting, it is better not to cultivate the entire surface of these small areas, but to leave some of the soil uncultivated to be used for later control if necessary.

Straw or manure is effective for control in these small areas, if a disk set straight or a similar implement is used immediately to cut them into the soil. If left loose, either of these may collect in piles or drifts and accumulate hummocks of soil.

If an entire field starts to blow, the surface should be put in a roughened and cloddy condition as soon as possible. This cultivation should be only deep enough to accomplish the desired results, because it may be necessary with returning winds to cultivate later in order again to turn up moist soil.

In extreme cases where soil has been drifting for some time, or where deep cultivation is necessary, a lister may be used; but shallower cultivation is desirable, if it will check drifting.

## ORGANIZATION OF THE UNITED STATES DEPARTMENT OF AGRICULTURE WHEN THIS PUBLICATION WAS LAST PRINTED

| | |
|---|---|
| *Secretary of Agriculture* | HENRY A. WALLACE. |
| *Under Secretary* | M. L. WILSON. |
| *Assistant Secretary* | HARRY L. BROWN. |
| *Director of Extension Work* | C. W. WARBURTON. |
| *Director of Finance* | W. A. JUMP. |
| *Director of Information* | M. S. EISENHOWER. |
| *Director of Personnel* | W. W. STOCKBERGER. |
| *Director of Research* | JAMES T. JARDINE. |
| *Solicitor* | MASTIN G. WHITE. |
| *Agricultural Adjustment Administration* | H. R. TOLLEY, *Administrator.* |
| *Bureau of Agricultural Economics* | A. G. BLACK, *Chief.* |
| *Bureau of Agricultural Engineering* | S. H. MCCRORY, *Chief.* |
| *Bureau of Animal Industry* | JOHN R. MOHLER, *Chief.* |
| *Bureau of Biological Survey* | IRA N. GABRIELSON, *Chief.* |
| *Bureau of Chemistry and Soils* | HENRY G. KNIGHT, *Chief.* |
| *Commodity Exchange Administration* | J. W. T. DUVEL, *Chief.* |
| *Bureau of Dairy Industry* | O. E. REED, *Chief.* |
| *Bureau of Entomology and Plant Quarantine* | LEE A. STRONG, *Chief.* |
| *Office of Experiment Stations* | JAMES T. JARDINE, *Chief.* |
| *Farm Security Administration* | W. W. ALEXANDER, *Administrator.* |
| *Food and Drug Administration* | WALTER G. CAMPBELL, *Chief.* |
| *Forest Service* | FERDINAND A. SILCOX, *Chief.* |
| *Bureau of Home Economics* | LOUISE STANLEY, *Chief.* |
| *Library* | CLARIBEL R. BARNETT, *Librarian.* |
| *Bureau of Plant Industry* | E. C. AUCHTER, *Chief.* |
| *Bureau of Public Roads* | THOMAS H. MACDONALD, *Chief.* |
| *Soil Conservation Service* | H. H. BENNETT, *Chief.* |
| *Weather Bureau* | WILLIS R. GREGG, *Chief.* |



U. S. GOVERNMENT PRINTING OFFICE: 1938

For sale by the Superintendent of Documents, Washington, D. C. - - - - - - - - Price 5 cents